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CONSUMPTION OF GAS AS AFFECTED BY POPULATION.*

By G. P. WATKINS and L. H. LUBARSKY.

The relation between population and the amount of use of transportation facilities has often been made a subject of statistical investigation. As regards street railways, in particular, it has been claimed that the number of passengers varies as the square of the population of the cities served. This hypothesis, as thus mathematically expressed, is questionable, but there can be no doubt that there is a rough functional relation between the population of a city or cities and the number of street railway rides, and that the increase of the latter is much more than in direct proportion to the increase of the former. If the choice is between mere proportional variation and the quadratic relation, the latter is much nearer the truth.†

The possibility of a similar relation between agglomeration (and, in a somewhat loose sense, density) of population and the extent to which the services of other public service enterprises are availed of is worthy of investigation, though the others are not so easily dealt with as the street railways. In the case of water supply the method of distributing the cost accords more with principles of taxation than with those of market price-making. The competition between electricity and gas—as regards use and consumption, if not always commercially—which is facilitated by the overlapping of the means of service, causes difficulties in the case of these utilities. It would be desirable to deal with light, heat, and power as separate services rendered the consumer, instead of with gas supply and electricity supply, thus avoiding the complication due to the substitution of electricity for gas. The present study is subject to an important limitation on this account.

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*The general division line between the work of the joint authors of this paper is: economic and statistical analysis mainly by Watkins, and graphic construction and analysis mainly by Lubarsky.

†For a discussion of this question by the writer of the above paragraph, see the Annual Report of the New York Public Service Commission for the First District for 1910, Vol. III, pp. 22–53; also a qualification of the conclusion in the similar report for 1912, Vol. II, p. 109, including the footnote.

In all these cases, there is the dynamic as well as the static aspect of the situation to be considered. The latter viewpoint relates to two or more cities of different size compared for the same date; the former relates to the same city at different times with regard to intervening growth of population. Time and progress enter greatly into the dynamic kind of comparison and but little into the static. The interest of the sort of study in question is at least as much dynamic as static. But the way to obtain an indication of the importance of the former element is to determine and make allowance for the importance of the latter, since even where time brings in other and possibly more important influences, mere population magnitude is a factor. Hence the two aspects of the general problem need to be studied together. It is too often assumed that there is a constant relation between population and consumption, or that the only cause of change in per capita consumption is a change in price. This assumption does not hold for urban public utilities, though it may sometimes be well enough, pragmatically speaking, to assume constancy of consumption, apart from price changes, for short periods of time.

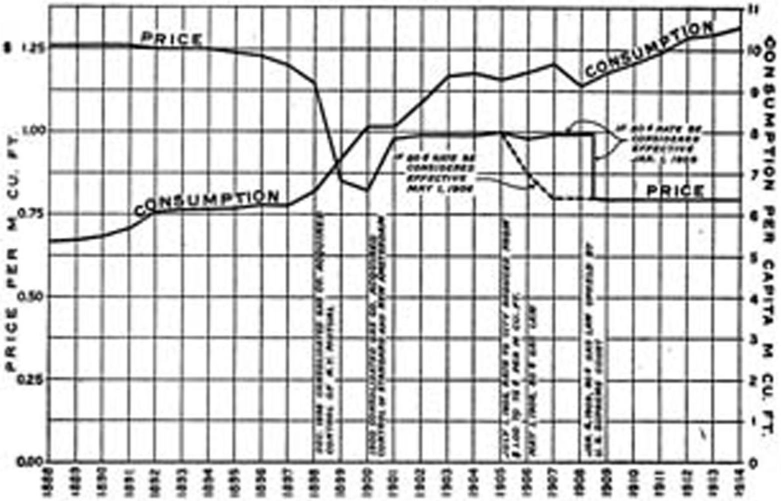
In the case of gas supply, it would be quite easy to attribute to differences in population results that are actually due to price differences, since the price per thousand itself bears in a general way a functual relation to the size of cities. Companies serving larger cities can usually afford to supply gas at lower rates. The lower price is, of course, a reciprocal effect of density of demand (larger per capita consumption) and of consequent "increasing returns," so that differences of the kind in question need not be dismissed as simply due to differences in price. But allowance needs to be made for this factor, that is, for the stimulating effect of a lower price upon consumption. The nearly uniform nickel street railway fare from place to place as well as from time to time in the United States is an important statistical advantage that is wanting in the case of the study of other utilities.

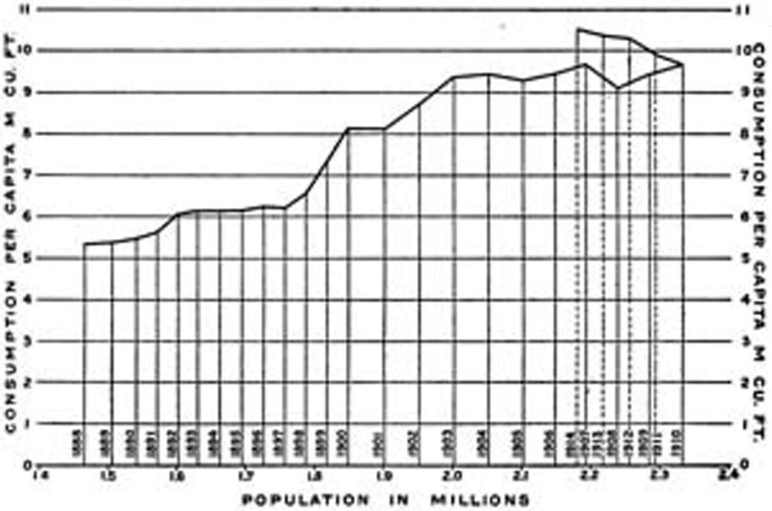
A dynamic factor of some independent interest is an increasing standard of living. The city dweller has doubtless considerably raised his standard in the past generation, at least as regards degree of per capita use of public utilities. As

(A) GROWTH OF GAS CONSUMPTION PER CAPITA AND AVERAGE PRICE

MANHATTAN BOROUGH, NEW YORK CITY

1888 – 1914





(B) VARIATION OF GAS CONSUMPTION WITH POPULATION IN VARIOUS YEARS

MANHATTAN BOROUGH

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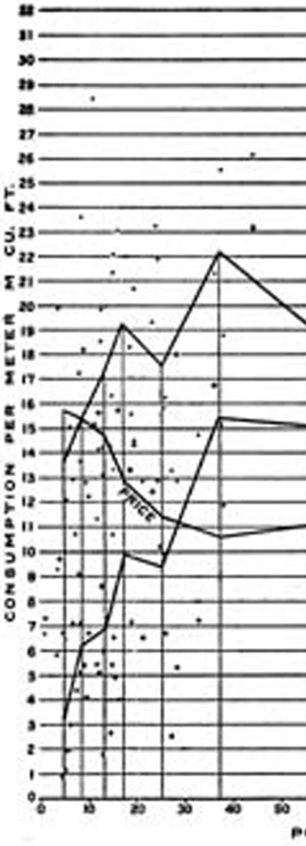

(C) VARIATIO

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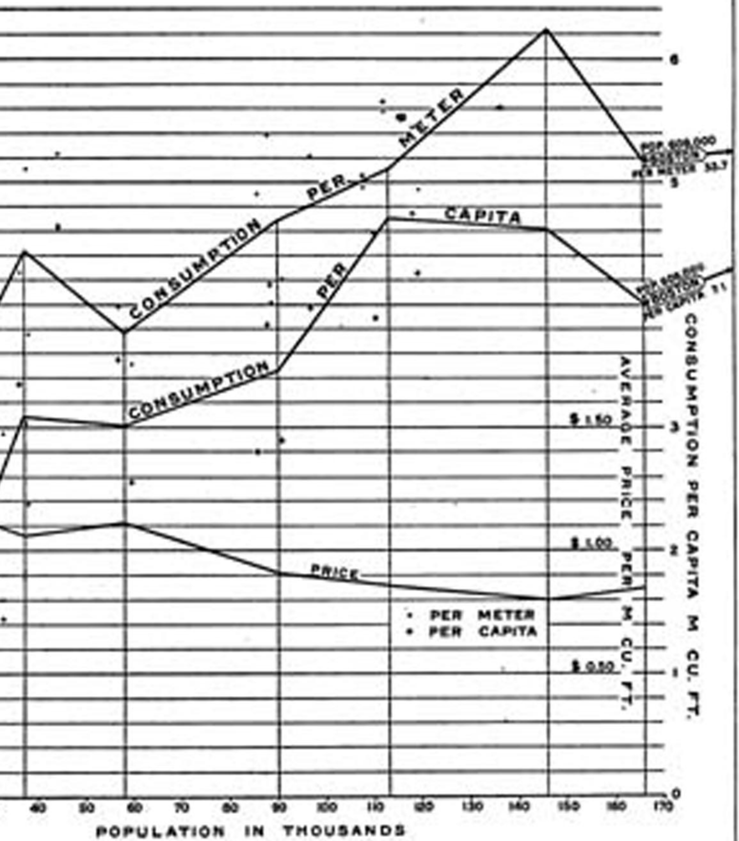
DIAGRAM I

ONSUMPTION OF GAS
IN RELATION TO
POPULATION



RIATION OF GAS CONSUMPTION
WITH
OPULATION IN VARIOUS LOCALITIES
MASSACHUSETTS, 1910

regards gas consumption, it should be noted that the higher standard often means the substitution of electricity for gas as an illuminant, and, on the other hand, of gas for coal in cooking and to some extent in other heat uses.

How much greater is gas consumption per consumer or per capita in a community having a large population than in one having a small population, is the subject of the present statistical investigation. The question is dealt with by the graphic method on the basis of such data as are available. The accompanying diagram which consists of three sub-diagrams, lettered A, B, and C, serves to determine how far per capita consumption is a function of varying population.

Sub-diagram A, the one in the upper left-hand quarter of the plate, shows primarily the growth in per capita consumption of gas in the Borough of Manhattan, City of New York, from 1888 to 1914. As the price of gas plays an important part in influencing consumption, another curve showing the average price per M cu. ft. for the same period is also shown in this sub-diagram. Sub-diagram B, in the lower left-hand section of the plate, utilizes the same data, but the consumption figures are geometrically coördinated with homologous populations. Both these sub-diagrams relate to the same urban territory, the variation in population and consumption depending on time.

The data for sub-diagram C have no relation to those for the other two. It shows that at the same point of time, the consumption of gas both per capita and per meter in different localities varies with the population of the locality. There is also an average price curve, which shows that price varies inversely as population; but the price variation is not as great as the variation of consumption. The data relate to localities in Massachusetts for 1910. The fact that, for gas consumption, figures of more recent date might be used is of little importance compared with the necessity of estimating corresponding populations that would accompany their use.* While serving mainly for comparison with and corroboration of results for New York City, the difference in the nature of the comparison should be noted. These Massachusetts figures are not directly affected by progressive changes with time—in other words, they show an economically static relation—while the New York City results may be due as much to the passage of time as to differences in population magnitudes—in other words, they are presumably dynamic in character.

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*The data of the present article were put into shape and the diagram constructed before 1915 figures were available.

The data used in the diagram are shown in the accompanying tables. The data of Table I are of independent interest. Those of Table II are of interest chiefly in connection with the diagram and therefore only such details are given as relate directly to the diagram and make it possible to identify the absolute numbers taken from the Massachusetts report. A detailed description of each sub-diagram together with a statement of its statistical significance follows the tables.

In connection with the population data of Table I, there is occasion to mention the probable deficiency of the 1890 federal enumeration of New York City with reference to its possible effect on the curves of the first two sub-diagrams. As is mentioned in a footnote to the table, allowance is made for this condition by arbitrarily increasing the Census figure for Manhattan Borough in 1890 by 100,000. According to the method employed to estimate population between decennial years the effect of any under or over estimation in the figure used is spread through the entire decade from 1890 to 1900 as well as before, and allowance could easily be made for it by the eye if occasion required.

As regards the Massachusetts localities, also, a qualification with reference to the population data is necessary. The population served by a particular gas company should strictly be, for comparative purposes, the number of inhabitants within reach of its mains. But population data of that nature are seldom to be had; nor does it make much difference if in the case of cities of medium or large size the territory taken in is determined by civil boundaries. In the case of small cities and towns some allowance for the effect of including people not within reach of the mains is necessary. Especially in Massachusetts, where the form of town government is such as to make the transition to organization as a city of little significance, the distinction between rural areas and areas whose population is incorporated as villages and cities, is scarcely applicable, the town government being adequate for many urban functions and the city, when organized, being territorially coextensive with its predecessor town. In fact the United States Census classifies the population of Massachusetts towns as urban or rural merely according to the number of inhabitants a town contains, the significance of an "incorporated place" being applicable in the ordinary sense only outside of New England. Hence the population of the smaller Massachusetts localities used in connection with this table may be misrepresentatively large in proportion to the number of inhabitants in position to be served by the gas companies.

The data for sub-diagram A are the two columns of derivative numbers of Table I. A few historical facts, having possible bearing on the direction of the curves at particular times, are noted at appropriate places on the diagram. The construction of the two curves needs little comment. As regards the price curve from 1905 to 1908, some explanation is necessary. On May 1, 1906, the price of gas for private consumers in the greater part of New York City was fixed at 80 cents per M cu. ft. by an act of the legislature passed the winter before. The gas companies operating in Manhattan took the matter to the courts and, pending a decision, the companies were allowed to charge the consumers $1.00 per M cu. ft., but the 20 cents excess was to be returned to the consumer if the 80 Cent Gas Law was held to be constitutional. On January 4, 1909, the United States Supreme Court upheld the law in question and the gas companies proceeded to refund the excess charge. Under these circumstances, there is room for question as to just what price should be compared with consumption per capita, but the preference should doubtless be given to the higher price, with a qualification. Both averages are shown in the price curve, the full line representing the price actually paid. The abrupt drop at the beginning of 1909 shows the change in the rate actually paid. The dotted curve between 1905 and 1909 shows the average price if the law be considered effective on May 1, 1906.

The curve of consumption per capita shows an almost steady upward tendency. The average consumption has practically doubled since 1888. The variations or increases from 1888 to 1897 were slight. From 1897 to 1903 there was a rapid increase of about 3 M cu. ft. This marked increase is explained by the great reduction in the average price of gas. There was a slight falling off in consumption per capita in 1908, reflecting the after effects of the 1907 panic. Since then the per capita consumption has been steadily rising, due largely to the final reduction in price to 80 cents.

The price curve shows a decrease of more than one third since the earliest year represented in the diagram. From 1898 to 1900 there appears to have been lively competition, which is reflected by the drop in the price from about $1.15 in 1898 to 82 cents in 1900. In 1901 the average price became about $1 per M and it remained there until the 80 Cent Gas Law became effective in 1909. But the effect of the reduction upon per capita consumption extends several years beyond this. From 1909 the price to the public has been constant, but per capita consumption has continued to move upwards. Throughout the period covered by the diagram the growth of the use of gas for industrial purposes and for cooking has doubtless been a factor in increasing per capita consumption.

Irregularities in the growth of population not reflected in the estimates used affect the detailed course of the curve considerably. It is probable that population increased less rapidly in 1913 and 1914 than in 1910-12. A slight peak appearing in 1907, also the salient angle at 1892 may be due to increases in population which the method of estimation of this element cannot well take account of.

Sub-diagram B is the graphic presentation of the same facts on a different plan. Of the coördinates of the series of points plotted, the abscissae represent particular populations, and the ordinates, corresponding per capita consumption. The scale for population is thus along the horizontal axis, and that for consumption along the vertical axis. Both axes have the same point of origin, which, however, is not shown on the diagram, since only the part of the space between the portion of the axes in question that contains the points plotted is significant. The population points for each year are located on the horizontal axis, and at each of them ordinates are drawn which are numerically proportional to the per capita consumption in each year. The population of the intercensal years having been determined as an arithmetic series, the intervals on the axis of abscissae between census figures are equal. So far as known, the maximum population was reached in 1910, the 1915 State Census figures for Manhattan Borough being considerably less than those for 1910.* Hence the ordinates for 1911, 1912, 1913 and 1914 recede instead of advance, and are therefore distinguished as dotted lines. The curve connecting the extremities of the ordinates chronologically reflects the direct movement of population until 1910, and the retrograde movement from 1910 to 1914. This curve is the same as the consumption curve of the first sub-diagram, only the yearly intervals are variable instead of being constant, and the ordinates advance as long as population increases and recede when population decreases.

The steady increase in per capita consumption is seen as before. But it is further shown that from 1910 on, although the population decreased, per capita consumption continued to increase. Hence per capita consumption cannot be said to be simply a function of population magnitude. It is influenced by factors apart from those directly affecting the growth of population in the territory served. The business and amusement district of Greater New York would naturally be indirectly favored by population growth occurring outside the borough that contains the most important of such interests. The rising standard of living would be similarly effective. It should be noted that from the point of view of judging of the general direction of the per capita curve as related to the growth of population, the second sub-diagram serves the purpose better than the first, since the slope of the curve changes as the rate of increase of population changes, with the exception, of course, of such irregularities as cannot be recognized in interpolating between census years. The slope is more nearly uniform in this curve than in the one above, though the effect of price changes is still marked.

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*The state enumeration of 1915 was probably deficient for New York City; nevertheless there appears to have been an actual decrease in the population of Manhattan Borough.

Sub-diagram C is based on Table II. The population figures are as of April 15, 1910, the meters as of June 30, 1910, and the metered gas as of the two year period from July 1, 1909, to June 30, 1911. By taking the average per year of metered gas for the two years, a figure is obtained that synchronizes with the date of the number of meters. The slight divergence of the population date is not important, especially for urban population.

The method of plotting the third sub-diagram is similar to that for the second. The horizontal axis denotes population and the vertical consumption per meter and per capita, also price per M cu. ft. The coördinates of each point plotted as a dot are the population and per meter consumption for a particular locality, and of those plotted as plus signs, population and per capita consumption. Hence there are a dot and a plus sign on every ordinate. To eliminate the irregularities resulting from the large number of small localities, the latter have been grouped as shown in part B of Table II, averages for population and for per meter and per capita consumption having been computed by groups. The average points for each of these various groups together with the points for the two large localities having populations of 165,900 and 146,000, respectively, are connected, giving the two curves of consumption per meter and consumption per capita, respectively. The largest locality is that served by the Boston Consolidated Gas, with 606,000 population, an average per meter consumption of 33.7, and an average per capita consumption of 7.1, the price being 80 cents per M. Owing to a limitation of the graphic method, it is impossible to locate these points on the diagram as drawn. The character of the curves as they would be extended beyond the right edge of the diagram is, however, indicated by arrows. The coördinates of the smaller localities are properly plotted individually, but the points are not connected.

As a necessary qualification of the significance of the other curves a price curve is added. The average price per M cu. ft. for each locality is given in the table, but only the average price for each group is plotted. In computing these average prices, sales to other gas companies have been eliminated.

The degree of certainty of the significance of the data would be greater if prices were constant. But with the aid of the price curve, allowance can be made for such differences. Differences in per capita consumption between large and small localities are doubtless partly due to the fact that it is in general the smaller communities that have the higher rates. But allowance for the price factor appears to leave a difference still to be accounted for by other factors, whose comparative importance will be considered presently.

There is much irregularity in the variation of per meter and per capita consumption with the size of population aggregates. But, as already indicated, the general trend is unquestionably towards increased consumption both per meter and per capita with increased population. For reasons already mentioned, less importance should be attached to the points and lines for localities under 20,000 population than to those for the larger localities. The small number of the cities in each group is also a reason why considerable irregularity above this population magnitude is to be expected.

The slope of the per capita curve in sub-diagram C is of course not directly comparable with that of the curve in subdiagram B. According to the trends of these two curves as roughly determined from the two sub-diagrams an increase of population in the same locality (Manhattan) of about 13 per cent. is accompanied by an increase of 50 per cent. in per capita gas consumption, while a relative difference in population between two separate localities for the same date must be 500 per cent. of the smaller population in order to correlate with a difference of 50 per cent. in per capita gas consumption. Of course such a comparison must be very rough. And it must be qualified with reference to price differences. The 50 per cent. increase in per capita gas consumption in Manhattan is accompanied by a 36 per cent. decrease in price. The 50 per cent. difference in per capita gas consumption among the Massachusetts localities is accompanied by about the same 36 per cent. difference in price. If we could attribute the whole difference in consumption to differences in price, assuming also that these rough quantitative inferences are sufficiently correct, then the demand curve for gas might be alleged to be a "constant outlay" curve, a one third decrease in price per unit being responded to by a one half increase in consumption, the aggregate price thus remaining the same. As to the relation between price and consumption the data would perhaps repay mathematical analysis by way of correlation coefficients.

From this result it might be inferred that price accounts for all the differences and changes in consumption. But for such a conclusion the comparison proves too much. It negates the influence of the dynamic as well as the static factors. The former certainly appear to count for something in the Manhattan curves. And as regards the static (Massachusetts) curves, while there is evidently a close inverse correlation between price and consumption, yet between 90,000 and 600,000 population, where there is the smallest range of variation in group average prices (10 cents) there is the greatest range in per capita consumption, that is, from 3.5 to 7.1.

Apart from the question of the influence of price, it is clear that dynamic factors are far more important than the mere size of the population aggregate. As a matter of fact, it is quite proper to class price among the dynamic factors, but it was the intention of the present study to abstract from the effect of price changes and price differences so far as possible. And there seems to be some ground for believing that mere aggregation of population does tend to increase gas consumption somewhat. The complexity of the problem is such that an attempt to specify how much is hardly warranted. And it may be necessary to conclude, at the same time, that the public appears to be able quickly to obtain for itself most of the benefit of density of consumption by means of a lower price, thus obscuring the effect upon consumption of agglomeration of population as such.

TABLE I.

POPULATION, SALES OF METERED GAS, AND REVENUE DERIVED THEREFROM, BOROUGH OF MANHATTAN, CITY OF NEW YORK, 1888-1914.

Year Ending Dec. 31.	Population. (a)	Sales of Gas (M cu. ft.) (b).	Sales per Capita. (M cu. ft.).	Revenue from Sale of Gas.	Average Price per M cu. ft.
1888	1,465,908	7,797,147	5.32	$9,824,405	$1.260
1889	1,503,562	8,075,509	5.37	10,175,141	1.260
1890	1,541,216	8,409,343	5.46	10,595,772	1.260
1891	1,572,104	8,819,804	5.61	11,122,953	1.261
1892	1,602,991	9,681,954	6.04	12,102,442	1.250
1893	1,633,879	9,979,014	6.11	12,473,767	1.250
1894	1,664,766	10,181,325	6.12	12,726,656	1.250
1895	1,695,654	10,402,830	6.13	12,899,509	1.240
1896	1,726,541	10,742,799	6.22	13,213,643	1.230
1897	1,757,429	10,900,965	6.20	13,081,158	1.200
1898	1,788,317	11,661,300	6.52	13,410,495	1.150
1899	1,819,205	13,325,943	7.33	11,327,052	.850
1900	1,850,093	15,036,787	8.13	12,330,165	.820
1901	1,900,660	15,476,533	8.14	15,167,003	.980
1902	1,951,227	17,004,702	8.71	16,834,655	.990
1903	2,001,794	18,725,618	9.35	18,538,362	.990
1904	2,052,361	19,415,818	9.46	19,221,659	.990
1905	2,102,928	19,540,243	9.29	19,540,243	1.000
1906	2,148,651	20,296,822	9.45	17,690,151 (c) 19,904,915	.872 .981
1907	2,194,374	21,227,252	9.67	17,003,439 (c) 21,094,699	.801 .994
1908	2,240,096	20,442,298	9.13	16,378,154 (c) 20,341,694	.801 .995
1909	2,285,819	21,656,335	9.47	17,287,177	.798
1910	2,331,542	22,583,176	9.69	18,037,196	.799
1911	2,293,846	22,730,971	9.91	18,154,275	.799
1912	2,256,150	23,247,816	10.30	18,571,457	.799
1913	2,218,454	23,015,070	10.37	18,385,758	.799
1914	2,180,758	22,940,883	10.52	18,322,321	.799
1915	(d) 2,143,061				

(a) Sources: United States Census for decennial years and New York State Census for 1905 and 1915, figures for intervening years being interpolated according to arithmetical progression. But the Census figure for 1890 is increased by 100,000 to allow for deficient enumeration.

(b) Sources: 1888-1905 City's Exhibit No. 46, in the printed record of the case of the ***Public Service Commission*** vs. ***the Consolidated Gas Co.***, Vol. V, p. 5745, also reproduced in William D. Mark's "Finances of Gas and Electric Light and Power Enterprises," opposite p. 398; 1906-1914, company returns furnished to Public Service Commission and its predecessor, the Board of Gas and Electricity. The four gas companies serving Manhattan Borough are the Consolidated, Standard, New York Mutual, and New Amsterdam. For 1907 and 1908 some estimation is necessary in order to put the figures on a calendar year basis.

(c) Includes 20 cents per M cu. ft. paid by the public pending decision of appeal of 80 Cent Gas Law.

(d) The figure for 1915 is preliminary and 5,314 larger than the final reported figure for New York County, but the enumeration appears to be considerably deficient.

TABLE II.

POPULATION, SALES OF METERED GAS TO CONSUMERS AND NUMBER OF METERS, FOR CERTAIN LOCALITIES IN MASSACHUSETTS, 1910.(a)

(A) SIGNIFICANT DATA FOR EACH LOCALITY.

Population of Territory Served (thousands).	Number of Meters.	Average Price per M cu. ft. (b)	Average Consumption per Meter.	Average Consumption per Capita.
606.4	128,170	$ .80	33.68	7.119
165.9	26,560	.854	25.92	4.149
146.0	21,626	.806	31.21	4.624
119.3	20,540	.845	24.71	4.255
118.5	20,577	.927	27.23	4.728
112.1	23,413	.780	27.24	5.688
110.2	18,763	.905	22.81	3.885
107.7	21,771	.871	24.80	5.015
96.7	14,841	.857	26.01	3.994
90.9	12,542	.876	21.01	2.898
88.4	18,347	.979	20.04	4.157
88.0	12,517	.94	26.99	3.838
85.9	9,793	.867	24.57	2.801
59.4	8,620	1.11	17.55	2.546
56.9	10,107	1.11	19.99	3.552
44.1	7,815	.931	26.21	4.644
37.8	4,793	1.14	18.81	2.383
37.5	4,444	.987	25.57	3.031
35.7	5,616	1.14	21.31	3.353
32.6	3,501	1.43	14.76	1.448
28.4	2,349	1.19	12.87	1.066
28.4	5,642	1.36	18.08	3.598
27.4	1,048	1.00	13.26	0.507
26.0	2,135	1.65	16.23	1.331
25.4	3,202	1.28	15.82	1.994
24.8	2,316	1.04	21.91	2.047
24.4	2,721	1.10	23.26	2.594
23.2	2,990	1.00	19.37	2.493
21.3	2,135	1.50	12.96	1.297
19.4	2,725	1.24	20.68	2.900
19.0	1,728	1.48	15.57	1.418
18.7	2,726	1.17	18.24	2.666
16.2	2,210	1.20	23.05	3.141
15.3	711	1.40	21.26	0.988
15.2	903	1.40	22.12	1.310
15.1	1,231	1.59	13.34	1.086
14.9	1,950	1.39	16.33	2.131
14.7	541	2.09	14.38	0.529
13.1	968	1.53	19.88	1.472
13.0	1,104	1.14	14.20	1.203
12.9	1,208	1.51	18.50	1.726
12.9	354	1.79	13.12	0.360
12.1	856	1.79	14.27	1.006
11.6	1,119	1.63	11.25	1.090
11.3	1,197	1.30	28.69	3.038
9.9	1,092	1.56	12.31	1.363
9.4	594	1.62	12.88	0.813
8.8	530	1.31	18.23	1.101
8.5	384	1.55	23.63	1.063
8.5	863	1.61	13.83	1.400
8.0	840	1.57	17.26	1.809
6.7	740	1.54	12.95	1.422
5.8	230	1.92	15.03	0.598
5.6	160	1.29	13.91	0.394
5.1	98	1.72	12.10	0.232
4.9	140	2.15	6.70	0.191
3.7	361	1.15	19.96	1.943
3.0	365	2.07	9.35	1.152
1.1	230	2.92	6.73	1.429

(a) Board of Gas & Electric Light Commissioners of the Commonwealth of Massachusetts, 1911, pp. 96, 241^{a}, 222^{a}. Acetylene gas companies are not included.

(b) Prices are for 1911 and are computed by using data on p. 226^{a} in conjunction with p. 229^{a}.

(B) SUMMARY FOR ALL DATA BY GROUPS OF LOCALITIES.

Size Class of Locality thousands).	Number of Localities (a) in Class.	Aggregate Population [illegible] 1910.	Average Population of [illegible] Class.	Average Price per M cu. ft.	Number of Meters June 30, 1910.	Consumption per Year (Average of 1910 and 1911) (M cu. ft.).	Consumption per Meter (M cu. ft.).	Consumption per Capita (M cu. ft.).
....	1	606,369	606,369	$ .80	128,170	316,518	33.68	7.119
....	1	165,924	165,924	.854	26,560	688,400	25.92	4.149
....	1	145,986	145,986	.806	21,626	675,045	31.21	4.624
120-100	5	567,772	113,554	.862	105,064	2,673,587	25.45	4.709
100- 80	5	449,974	89,995	.907	68,040	1,595,679	23.45	3.546
60- 50	2	116,296	58,148	1.11	18,727	353,292	18.87	3.038
45- 30	5	187,765	37,553	1.06	26,169	580,021	22.16	3.089
30- 20	9	229,294	25,477	1.14	24,538	431,016	17.58	1.880
20- 15	7	118,945	16,992	1.29	12,234	235,425	19.24	1.979
15- 10	9	116,603	12,956	1.47	9,297	160,690	17.28	1.378
10- 6	7	59,861	8,552	1.54	5,043	75,837	15.04	1.267
6- 2	6	28,125	4,688	1.57	1,354	18,423	13.60	0.655
Under 2(b)	1	1,084	1,084	2.92	230	1,548	6.73	1.429

(a) "Locality" means territory served by a particular company so far as population returns permit of such a division or combination of data. The population figures are from the Federal Census as used by the Massachusetts Board.

(b) Not used in plotting the curves.